NOAA Technical Memorandum ERL NSSL-97

J.P. FINLEY: THE FIRST SEVERE STORMS FORECASTER

Joseph G. Galway

National Severe Storms Laboratory
Norman, Oklahoma
November 1984

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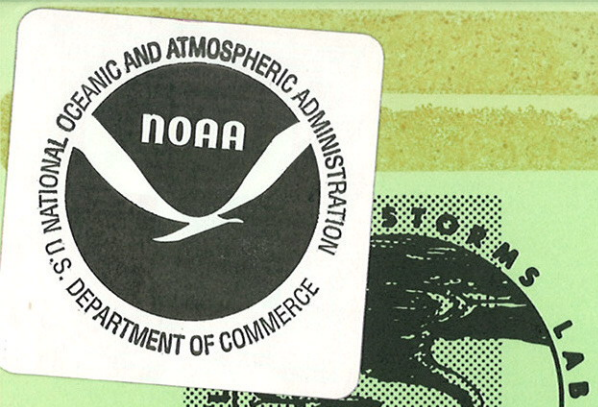

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NATIONAL SEVERE STORMS LABORATORY TECHNICAL MEMORANDA

The National Severe Storms Laboratory, Norman, Oklahoma, in cooperation with other government groups and with units of commerce and education, seeks understanding of tornadoes, squall lines, thunderstorms, and related local storms and rain; develops and applies methods for their observation and prediction; and examines possibilities for their beneficial modification.

Reports by the cooperating groups are printed as NSSL Technical Memoranda, a subseries of the NOAA Technical Memorandum series, to facilitate prompt communication of information to vitally interested parties and to elicit their constructive comments. These Memoranda are not formal scientific publications.

The NSSL Technical Memoranda, beginning with No. 28, continue the sequence established by the U.S. Weather Bureau National Severe Storms Project, Kansas City, Missouri. Numbers 1-22 were designated NSSP Reports. Numbers 23-27 were NSSL Reports, and 24-27 appeared as a subseries of Weather Bureau Technical Notes.

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UNITED STATES
DEPARTMENT OF COMMERCE

Malcolm Baldrige,
Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION

Environmental Research
Laboratories

Vernon E. Derr
Director

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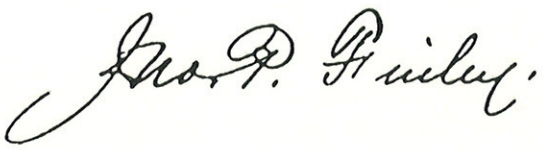
We are swept up by the excitement of current work and may rarely examine or reflect on the scientific contributions of our predecessors. But such examination and reflection give rich dividends: in enhanced sense of community and connection, and of the significance of our work in history; frequently an appreciation of early remarkable insights gained with aids inferior to those available today; and sometimes even an important finding developed long ago but since forgotten. We are therefore much indebted to weather forecaster Joseph Galway, whose meticulous research into the life of an early great student of meteorology is presented here. We at NSSL are complimented to have Mr. Galway's work in our series of Technical Memoranda.

Edwin Kessler
Director, NSSL

LIEUTENANT JOHN P. FINLEY, SIGNAL CORPS, UNITED STATES ARMY.



(Woodcut taken from Harper's Weekly, 32:945, December 8, 1888.)

J. P. FINLEY: THE FIRST SEVERE STORMS FORECASTER

Joseph G. Galway*

ABSTRACT

During the 19th century, while others were debating about the theory and morphology of tornadoes, Finley set out to prove that tornadoes, like other weather phenomena, could be forecast. He developed forecast rules and made experimental forecasts. His forecasting and analysis activities made him the center of controversy during most of his professional life and led to open debate in the literature, but he set precedents in meteorological forecasting that are still valid today. His career as a meteorologist started while he was a private in the U.S. Army. His interest continued even when he had achieved the rank of Captain and was Civil Governor of Zamboanga in the Phillipines. After his retirement as a Colonel he again became active as a private meteorologist, first establishing a business that provided insurance underwriters with meteorological data for assessing risks, and then opening a school of theoretical and applied meteorology and climatology.

1. FINLEY AS A MILITARY METEOROLOGIST

John Park Finley was born at Ann Arbor, Mich., on April 11, 1854, the son of Florus Samuel Finley, a prominent and rather well-to-do farmer of Ypsilanti, Mich. Finley received his primary education in the Ypsilanti school system and completed the course in classical education at the State Normal College (now Eastern Michigan State) in 1869. He entered Michigan State Agricultural and Mechanical College (now Michigan State University) in 1870 and graduated with a Bachelor of Science degree in 1873. In 1882 he received a Master of Science degree from Michigan A & M in recognition of his proficiency in the science of meteorology. His educational credits also include a 1-year course in the Law Department at the University of Michigan during the academic year 1874-1875 (Finley Papers, 1890a). After completing his schooling, Finley returned briefly to the family farm, but early in 1877 he enlisted in the U.S. Army Signal Service (later called the Signal Corps).

When Finley enlisted, he was large in stature, standing 6 feet 3 inches and weighing close to 200 pounds, a weight that would increase beyond control later in his military career. Subsequent Army medical

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examinations would constantly report him in excellent physical condition and a man with "no bad habits." He was sent to the Signal Service school at Ft. Whipple, Va. (Ft. Whipple was re-named Ft. Meyer in 1880 after the death of General Albert J. Meyer, Chief Signal Officer and first head of the Signal Corps weather service.) Finley's training for assistant to the non-commissioned officer in charge of a weather station began on April 26, 1877 (RCSO, 1878). The instruction consisted of courses in military tactics, signaling, telegraphy, telegraphic line construction, electricity, meteorology, and practical work in meteorological observation. (Later, in 1882, a course for commissioned officers covering meteorology, mathematics, electricity, and laboratory work was added to this school.) Finley completed his Army schooling and was ordered to Washington, D.C., as an assistant in the office of the Chief Signal Officer on July 18, 1877. However, he was immediately detailed as assistant to the sergeant in charge of the Signal Service station in Philadelphia, Pa., and remained there until October 1877. It was while he was stationed at Philadelphia that Finley's interest in tornadoes began. He wrote that he started "a systematic study of the storms of the United States, especially those of a violent character, namely, tornadoes." In 1878 he prepared his first paper on the subject, which was submitted to the Chief Signal Officer (Finley Papers, 1883).

This paper was never published, and what first whetted Finley's interest in tornadoes may never be known. Whether the occurrence of tornadoes in the vicinity of Philadelphia during the summer of 1877 sparked his interest, or whether it was a prior deep-seated fascination for this particular weather phenomenon, is a matter of pure speculation. The first effort by Finley to publish was referred to by Cleveland Abbe, chief scientist for the Signal Corps, some years later before a Congressional Committee. Abbe testified, in reference to Finley's tornado work,

> "He then devoted all his spare private time to the study of tornadoes, and compiled a very elaborate report on the matter, which was submitted, and in fact approved, for publication; but in some way this manuscript was mysteriously and suspiciously lost..."(Allison Commission, 1886a).

Upon his return to Washington, Finley was assigned as assistant in the "Fact Room" (Finley Papers, 1883). It was here that the Monthly Weather Review and the Weekly Weather Chronicle were prepared. Finley would help in the preparation of these publications until 1882. (The Fact Room was later renamed "Fact and International Bulletin Room.")

It was the custom of the Signal Service at that time to send an observer into an area that had been devastated by tornadoes to make an extensive survey. In some cases, it was to survey the site of a single tornado that had caused a large death toll. The Signal Service instructions for conducting a tornado survey were voluminous and all-encompassing, as were the reports that were subsequently submitted (RCSO,

1873). Finley was ordered to make a survey on a rash of tornadoes that occurred in the Central Plains late in May 1879. His report was completed by September and appeared in the "Report of the Chief Signal Officer for 1880." In 1881, it was published as a Signal Service Professional Paper (Finley, 1881). Although other detailed accounts of tornadoes had appeared in Signal Service publications and elsewhere prior to Finley's 1881 report, no one had been so impudent as to suggest the establishment of a unit in Kansas City, Mo., to forewarn of possible tornadic activity. Finley wrote,

> "Permit me to suggest that it would be advisable, and without doubt practicable, to station a special observer during the months of May, June, and July at Kansas City (a point easily communicated with from any part of the Lower Missouri Valley), who shall receive special reports and instructions from Washington regarding atmospheric disturbances and report the same to the various telegraphic stations throughout the valley".

Finley was a prophet. In 1952 the U.S. Weather Bureau began issuing tornado forecasts (now watches) alerting the public that the potential for tornado activity existed. When the forecast unit was transferred to Kansas City in the late summer of 1954, one of the reasons given was that Kansas City was a favorable communication center.

There is no doubt that Finley's first offering and his avid interest in tornadoes impressed his superiors. He was promoted to private first class by the end of 1879 and given permission to continue his tornado studies. Finley also had an interest in bettering himself, as avid as that for tornadoes. In August 1879 he requested an appearance before the Examining Board that was screening applicants for the rank of Second Lieutenant. But Finley's request was not honored at that time. During this period there was an administrative change in the Signal Service -- one that helped catapult Finley into recognition. General Meyer died in August 1880, and was succeeded by General William B. Hazen. Meyer had not been overly interested in research (Popkin, 1967). He employed one research scientist, Professor Cleveland Abbe, who was also the chief forecaster for the weather service.[1] Hazen, being more research oriented, hired four senior and three junior scientists after he took command and in 1881 established a research unit called the "study room" at Ft. Meyer to which Finley would be assigned in 1884 (Popkin, 1967).

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[1] All forecasts, or (as they were called) "probabilities", were issued from the Washington headquarters by Abbe until 1873 when this duty was assumed by Signal Corps officers. The designation "probabilities" was changed to "indications" late in 1876 and to "forecasts" in April 1889. Abbe issued the first "probabilities" in February 1871 (Weber, 1922).

Finley continued to work in the Fact Room and in addition collected all known tornado reports from old records that covered the period 1794 through 1881. This was the project that he had begun in Philadelphia and that would appear as a report in early 1882 entitled "The Character of 600 Tornadoes." The first version contained many errors, some typographical. The paper was suppressed, corrected, and finally published as a Signal Service Professional Paper (Finley, 1884a). It consisted of the most comprehensive climatology on tornadoes set forth up to that time. More important, his deductions in that paper became the foundation for a list of forecast rules that were developed over the next year or two, culminating in experimental forecasts for tornadoes up to 16 hours in advance by Finley.

The year 1882 was one in which Finley's emotions included both elation and despair. Finley re-enlisted in the Signal Corps in March 1882 as a Sergeant, a rank that he attained in April 1881. His suggestion that appeared in Professional Papers Numbers 4 and 7 (first version) for the reporting and investigation of tornadoes led to his belief that a permanent system should be established. "This system was to embrace not only what might be attained in the investigation of a single tornado, but to afford means for the elaborate study of these storms during an entire season or continuously year to year (RCSO, 1884)." He was assigned the task of testing the feasibility of this plan, named the "Tornado Studies" project, attached to the office of the Chief Signal Officer in Washington in April 1882. Finley moved his base of operations to Kansas City, Mo., and traveled extensively through Arkansas, Missouri, Kansas, Nebraska, Iowa, Illinois, and Michigan during the spring of 1882 enlisting tornado spotters, then called "tornado reporters", for his reporting network.

Finley returned to Washington in the fall of 1882 to compile the tornado reports collected during the spring and summer. On October 4, 1882, Sgt. Finley received orders from Gen. Hazen to proceed to Baltimore, Md., and enroll at Johns Hopkins University as a graduate student in preparation for carrying on the investigation of the subject of tornadoes and cyclones (Hamburger, 1882a). Finley applied for admission to Johns Hopkins on October 9, 1882.

While working on studies at Johns Hopkins, completing the tornado studies of 1882, and suggesting a meteorological observatory at the university, Finley found time to marry Julia V. Larkin on November 18, 1882. Less than a month later, the responsibility of assuming charge of the Tornado Studies project, and his extensive travels earlier in the year, coupled with the course work at Johns Hopkins and excitment of his recent marriage, brought Finley to a point of nervous exhaustion. He was confined to an Army hospital in Washington, D.C. A report from the attending physician to Gen. Hazen on December 16, 1882, stated,

> "I have just made an examination of Sgt. J.P. Finley, S.C., U.S. Army and find him suffering

> from premonitory symptoms of Neurasthenia. He is doing too much brain work. He very decidedly needs rest. Should he continue to do as much as at present the consequences will be of very grave character" (Hamburger, 1882b).

Finley never did return to complete his studies at Johns Hopkins. In a letter to an acquaintance in April 1883, he commented that "his illness had caused him worlds of regret and that he trembled at the prospect of retrograding at a time when thought was so rapidly progressing" (Hamburger, 1883). Finley did not retrograde. He corresponded again on May 22, 1883, from the U.S. Signal Station in Detroit, Mich., making no mention of his illness. The tenor of the letter was that of his writings and correspondence prior to December 1882.

The results of Finley's efforts in establishing a tornado reporting network during 1882 and 1883 is reflected in the "Local Storms" section of the Monthly Weather Review for April, May, and June of 1883. This section ran four to five pages in each of these months, compared with one or two pages a month in previous years. There is no doubt that Finley prepared this section; the style and attention to detail resemble his previous output. Finley continued to increase his reporting network. A "large number" of additional tornado reporters were recruited on a voluntary basis and "without expense" to the Signal Service, and by the end of June 1884 Finley had assembled a network of 957 tornado reporters.

The Tornado Studies project was transferred from the office of the Chief Signal Officer to the study room in January 1884 with Finley in charge. Several hundred reports of tornadoes were received from the reporting network during the year and a series of charts depicting the special features of groups of tornadoes for selected dates in 1884 were published in preliminary form. These charts and a listing of the tornadoes for that year formally appeared as Professional Paper Number 16 of the Signal Service in 1885. This series included the famous tornado outbreak of February 19, 1884. Finley recorded 60 tornadoes that occurred on that day in southeastern U.S. and he estimated the death toll at 800.

The most significant event regarding the activities of the Tornado Studies project in 1884 was the beginning of experimental tornado predictions on March 10, 1884. These were made from the 7 a.m. (Washington time) weather map and covered the 8-hour period up to 3 p.m. A second prediction was made after a study of the afternoon weather map (3 p.m.) and covered the next 8 hours until 11 p.m. During March and part of April predictions were made twice daily but for the remainder of April and for May and June, Finley made only one prediction a day that covered a 16-hour period until 11 p.m.

Finley's method of verifying his predictions was unique. He divided the country east of 105°W into 18 districts (Fig. 1). The districts were somewhat biased toward maps of geographical distribution of tornadoes that

appeared in Professional Paper Number 7. Each district was divided into four equal parts, and predictions were made for the entire district or for any one or more of the parts. The predictions were dualistic in nature: they included conditions favorable and unfavorable for tornado activity. Finley considered both to be positive predictions, because, as he wrote, "it requires as much, and often more, study to say that no tornadoes will occur as to make the prediction that conditions are favorable for their development" (Finley, 1884b). This statement is still true a century later.

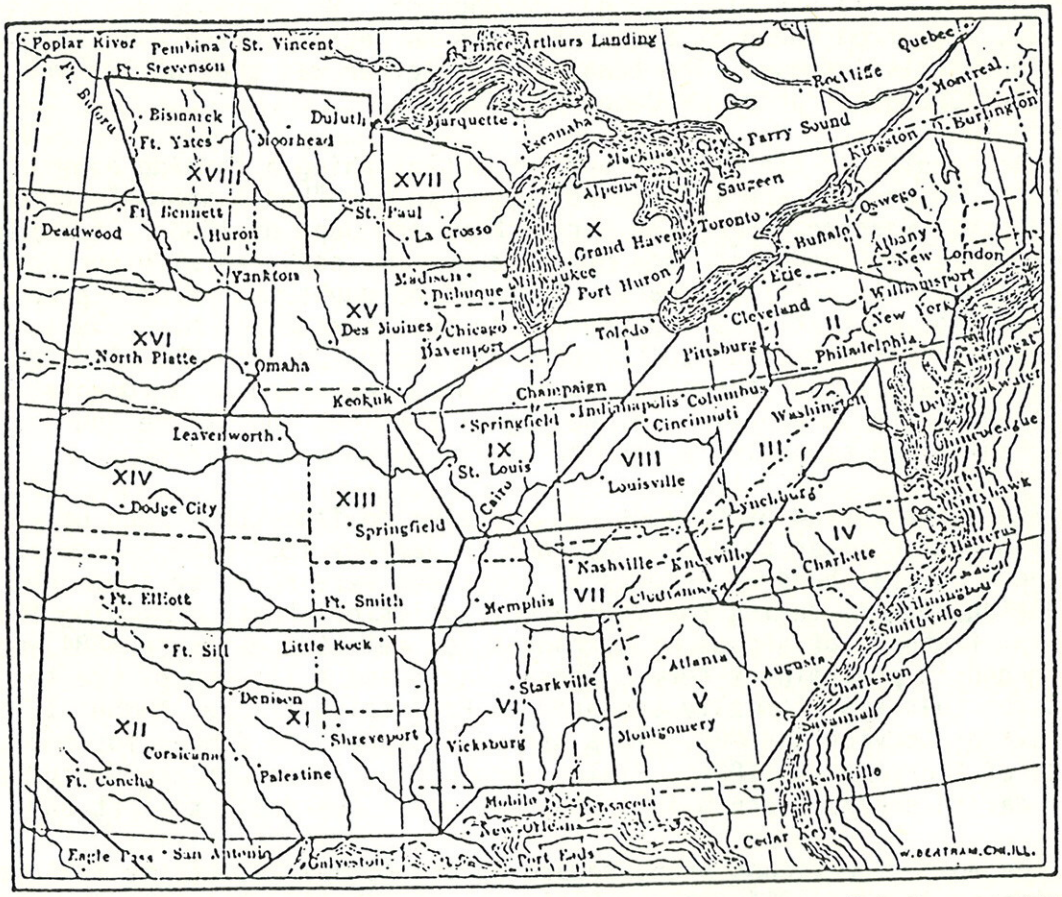

Figure 1. Finley's districts for tornado predictions (Finley, 1984d).

He published his results for the first three months of this experiment in the American Meteorological Journal for July 1884 and, on the basis of his verification scheme, he attained a 96.6% degree of success. However, when conditions favorable for tornado occurrence were predicted, only 28 of the 100 predictions were fully verified. The failure in the category "unfavorable conditions for tornadoes" amounted to 1%. Finley continued these daily predictions until August 1, 1884.

Finley's tornado studies were not his only assignment during 1883 and 1884. There appeared in 1884 Professional Paper of the Signal Service, Number 14, "Charts of Relative Storm Frequency for a Portion of the Northern Hemisphere." These charts illustrated monthly and annual distribution of tracks of centers of barometric minima over North America, the North Atlantic Ocean, and Europe for a 14-year period (four years of which were incomplete). The charts were intended to be of interest and value to navigators of the North Atlantic. Finley made no attempt to explain any of the peculiarities of the distribution in the storm track frequency figures he assembled.

Five years after his initial application, upon the recommendation of the Chief Signal Officer, Finley was commissioned a Second Lieutenant in the Signal Corps in July 1884 as a result of his tornado studies (Allison Commission, 1886b). He was sent to Ft. Meyer again for instruction in military signaling and the advanced meteorology course for officers. In February 1885 he was withdrawn from the course and assigned the duties of inspector of Signal Service stations throughout the country. In addition, he was instructed to visit the chairman of the local meteorological committee, if one existed, at the station location and inquire as to the conduct and performance of the observers (RCSO, 1879). Finley took advantage of the opportunity to speak before various educational and scientific groups on his tornado work, and to recruit additional tornado reporters. He served as inspector until May 1885.

Finley returned to Ft. Meyer and completed the prescribed course for officers, after which he was assigned to the Tornado Studies project in the Office of Chief Signal Officer and resumed his tornado predictions in June 1885. According to his report dated June 30, 1885, the number of tornado reporters had increased to 1307. Finley's stay in Washington was brief. He was sent out again to inspect Signal Service stations during August and September 1885.

The combination of Finley's apparent success at predicting tornadoes and his persistent belief that these predictions should be incorporated into official releases ("indications") of the Signal Corps, elicited instructions issued by the Chief Signal Officer in 1885: When the current weather report favored the occurrence of tornadoes, the indications would contain a special warning that violent local storms were indicated for the area of concern. The instructions also stated that the word "tornadoes" would not be used (RCSO, 1885).

There can be no question that Finley had outside support, solicited or otherwise, for his tornado predictions. The foregoing instructions were reissued in 1886 with the provision that the directors of the Minnesota, Ohio, and Alabama State weather services be informed when their regions were threatened.

At a time when Finley's tornado studies were at their peak, events were transpiring that would not only threaten his military career but

would also result in the eventual transfer of the weather service from military to civilian control. Prior to the establishment of the weather service under the Signal Corps in 1870, there was some question as to where such a service should be placed in the government. The controversy between groups that favored civilian control of the weather service and those that sponsored military control became a political issue. Budgetary limitations imposed by Congress on the weather service resulted in a reduction of services and produced numerous complaints from the civilian sector. These, plus an embezzlement scandal within the Signal Corps (Whitnah, 1961), prompted a far-reaching investigation of the Corps by Congress. This investigation, known as the Allison Commission, was conducted from 1884 into 1886. The Allison Commission report of June 1886 urged that the weather service be removed from Army control and recommended that it be placed under the jurisdiction of the War Department and that the training center at Ft. Meyer be closed. This meant the demise of the study room.

The sudden removal of Finley from his course of instruction at Ft. Meyer had been prompted by his appearance before the Allison Commission in January 1885. While Finley's testimony before the Allison Commission and his subsequent report to it (a summary of his tornado investigations) were innocent and valid, they included material that could be used by those who claimed the Signal Corps should not be in the field of basic research, an area they postulated was better suited to the civilian scientific community. In addition, Finley was one of four officers accused of harsh and abusive treatment of the enlisted personnel at Ft. Meyer (Allison Commission, 1886c). Finley, already a controversial figure within the Signal Corps, was sent on an inspection detail.

Prior to the release of the Allison Commission report and subsequent orders for closing the study room, Finley's Tornado Studies project had been moved from Ft. Meyer to Washington, D.C., in November 1885 by orders of General Hazen. Hazen recommended the change in order that Finley might "devote more time to the prosecution of his special studies of tornadoes, and which work can be properly done by constant reference to the records and charts of this office (Washington headquarters)" (Finley Papers, 1885). Early in 1886, Finley was placed in charge of the Meteorological Record Division. The main function of this division was to check the meteorological observations and correct errors found in them.

Finley summarized the work performed since the establishment of the Tornado Studies project through June 1886 in his report to the Chief Signal Officer for that year. He listed the number of tornado circulars prepared for the tornado reporters (23), his own professional papers written (4), the number of tornado reporters enlisted in the network (1562), and the number of months for which tornado predictions had been made (12 1/2). The number of tornado predictions during a 3-month period in 1884 was 2812. This was to be the last comprehensive report of the Tornado Studies project, as the effects of the Allison Commission report began to be felt throughout the entire weather service. Finley also had

fallen from General Hazen's grace because he had testified before the Allison Commission that he "spent 17 hours a day on military duties, classroom training and his tornado studies" at Ft. Meyer, a statement to which Hazen had to respond to the Commission (Allison Commission, 1886d).

Finley was assigned to the Indications Division in July 1886, but his role as Indications Officer was short lived because later instructions restricted membership on the indications board (forecasters) to those who had experience in the preparation of indications (RCSO, 1887a). He did remain active in the division, assisting in the verification of indications through May of 1887. He was temporarily assigned as Indications Officer for the month of July 1887 during which his success as a general weather forecaster was indifferent.

In November 1886 General Hazen detailed Finley to New York City to assume command of the Signal Corps station there and to assist the maritime agencies of the Northeast Atlantic Coast with storm warnings. There he established a system of daily storm warnings for the North Atlantic, which were cabled to London and Paris. Hazen became ill soon after Finley arrived in New York, and the Acting Chief Signal Officer, General Adolphous W. Greely, ordered Finley to return to Washington in mid-December 1886. After Hazen's death in January 1887, Greely assumed command of the Signal Corps, a fact that would put more restraint on Finley's tornado work. Hazen, up until his death, believed in military control of the weather service, both the forecasting and the research activities. He had retained the civilian scientists after the closing of the study room, placing them in various divisions of the headquarters but allowing them to perform their studies as "additional duties", as was the case with Finley. However, Greely could not control the smoldering feud between the military officers and civilian scientists of the Corps and proposed in 1889 a reduction by one-third of the officers assigned and an almost 60% reduction in the enlisted corps (Whitnah, 1961). This was an obvious victory for those seeking civilian control of the service and one in which Finley would personally be embroiled.

In March 1887, at the central office, Greely established a new Records Division under the "attentive care" of Finley (RCSO, 1887b). The Tornado Studies project was incorporated into the Records Division. The report of the Records Division in June 1887 contained two items about the project on tornadoes. One was that the number of tornado reporters throughout the country had attained a figure of 2376. The other was that the majority of the activity in the project on tornadoes dealt with the routine compilation of tornado reports received. No mention was made of tornado predictions. There can be no question that Finley was ordered to discontinue his predictions; the Report of the Chief Signal Officer for 1887 quite pointedly declared that "it is believed that the harm done by such a prediction would eventually be greater than that which results from the tornado itself (RCSO, 1887c)."

Finley remained in command of the Records Division where he "devoted himself to his duties with marked zeal and assiduity" (RCSO, 1889a) until June 1889. However, in his report as Records Officer for 1888, the activity of the Tornado Studies project appears as "tornado work" and the report reflects the de-emphasis in this area: "During the latter half of the past year, but little attention has been paid to this branch of the division's work" (RCSO, 1888). He pleaded for a continued climatology of tornado reports, citing the long expenditure of time and labor of prior years. His report also notes that the number of tornado reporters was 2403, the highest ever.

A final effort by Finley to sustain his tornado work appears in his Records Division report of 1889 (RCSO, 1889b). One item in this last official report on Finley's investigations of tornadoes, remains with us today. General Orders Number 2 issued in January 1889 by order of the Chief Signal Officer instructed that no storm should be called a tornado "unless there is noted a well-defined pendent, funnel-shaped cloud, with attendant rotary winds." The substance of this definition is still valid. But the death knell had already been sounded on Finley's tornado work and reporting system. It only remained for the coup de grâce to be delivered, and that occurred late in 1889 and in 1890.

The Report of the Chief Signal Officer for 1890 contained a section on "Scientific Research," including this statement: "Impressed with the number and violence of destructive tornadoes during the past year, it is believed that an investigation of phenomena of this kind on their numbers, area devastated, lives lost, and other such information might be of current interest. This work was intrusted to Professor H.A. Hazen, who has given much time and attention to these phenomena" (RCSO, 1890a). Professor Hazen had replaced Finley as the Signal Corps spokesman and authority on tornadoes. Hazen had been an assistant professor in the study room and when this was abandoned, worked under Finley in the Records Division. He was Finley's most ardent and persistent critic. In his summary, the Chief Signal Officer noted that the average annual death rate from tornadoes was 102 over a period of 18 years but in 1890, from March through August, 102 lives were lost by lightning, "and in compiling this record the list is incomplete....it may be safely assumed that, dangerous as are tornadoes, they are not so destructive to life as thunderstorms" (RCSO, 1890b).

When Finley was relieved of his responsibilities for the Records Division during the summer of 1889, he was assigned to the Signal Corps station in Boston, Mass., where he was also in charge of the military telegraph lines for Massachusetts and Rhode Island. It was while in Boston that he was informed by the American Meteorological Journal that he had won first prize on Tornado Essays, offered by that journal in open competition. His successor as spokesman on tornadoes for the Signal Corps, H.A. Hazen, placed third behind Finley and A. McAdie, a doctoral student at Clark University, Worcester, Mass. (Prize Essays, 1890). Finley remained at Boston until May 1890 when he was ordered to San Francisco to assume charge of the new forecast office there. Finley took

command of the San Francisco office in July, although he had been on the west coast since June inspecting stations.

As a result of his tornado studies, Finley was not entirely unknown in the Pacific Coast states. By his activities as forecast official of the San Francisco office, his name became more familiar throughout the area. Finley knew the advantage of having a favorable press and cultivated it at every opportunity. Three fortuitous events in the latter months of 1890 helped spread Finley's name and reputation. Although early fall had been relatively dry, one storm moved in from the Pacific in early October. Finley predicted rain and had the foresight to telegraph the sergeant in charge of the Fresno Signal Corps station to alert the raisin growers so they could protect their crops.

The second event came in November when the Report of the Chief Signal Officer for 1890 was released. In it, General Greely stated that thunderstorms "were more destructive to life" than tornadoes. The reaction by the press to this statement was almost instantaneous. The Salt Lake City Times went to some length to prove Greely's inconsistency by quoting from Greely's own book "American Weather", published in 1888, which read, "in matters of tornadoes, Lt. John P. Finley is the one recognized authority, not only in this country, but abroad" (Finley Papers, 1890b).

The third event was a prediction. Dry conditions had continued through October and November, reaching drought proportions in the San Francisco area. On December 1 a large storm was detected approaching the coast, and Finley predicted the end of the drought. Heavy rains swept the length of California for two or three days bringing much-needed relief. It also brought Finley additional praise and recognition, deservedly so, from the populace and the press. The accurate prediction and attendant publicity came at a very opportune time for Finley. He was in the midst of a battle to save his military career.

General Greely's proposal to Congress to reduce the number of second lieutenants by one-third in 1889, plus a rather damaging efficiency report on Finley by Greely in May 1890, had placed Finley's career in an untenable position. The majority of the Signal Corps officers were "line officers"; that is, they received their military training in the infantry, artillery, etc., and then were assigned to the Signal Corps. A small group of officers, including Finley, although college graduates, received their military training at Ft. Meyer, which was considered inadequate by the line officers. The efficiency rating by Greely was not only a blow to Finley's ego but it infuriated him. Portions of the rating read,

> "...Has moderate ability in discussing weather data and to somewhat less degree in weather forecasting. Is unsuited for any duty involving the control or handling of any large number of men, as he is lacking in administrative work which demands clear, unbiased judgment and breadth of thought. Cannot

> organize, but is himself one of the most indefatigable workers the Chief Signal Officer has ever known.... Fair education; indomitable energy; excellent habits; and will always be a most valuable subordinate officer. Is not successful with his subordinates, as he is apt to be unreasonable in his demands upon their time, expecting from all the same intense application he himself displays. Stood No. 6 (general standing 67.2) in a class of 7 officers, after undergoing a year's instruction. Failed to be recommended (in July 1886, by the Board of Officers who examined the class) as competent for all the duties, civil and military, connected with the Signal Service" (Finley Papers, 1890c).

Finley prided himself on being a member of the Royal Society of Science, Letters and Art, London; the French Meteorological Society; and the American Association for the Advancement of Science, just to name a few. Greely's assessment of his scientific abilities hurt. However, it was not until Congress passed an act on October 1, 1890, transferring the weather service from the Signal Corps to the Department of Agriculture that Finley made his move to retain his status in the military.

Finley's defense for both his retention in the military service and his eligibility for promotion to First Lieutenant was threefold. First, the efficiency rating by Greely was based on a biased report made by Gen. Hazen some four years previous. Second, Greely chose to ignore the scientific achievements of the junior officers of the Signal Corps and, indeed, downgraded these contributions publicly. And third, while Finley followed military procedures by submitting statements of qualifications, accomplishments, abilities, and the like to the Chief Signal Officer, a duplicate set plus his assessment of the "in fighting" within the Signal Corps were sent to an influential third party. This was Finley's uncle, Hiram Berdan, who lived in Washington. Berdan was the same Colonel Berdan who had formed Berdan's Sharpshooters for the Army of the Potomac during the Civil War. Berdan and his sharpshooters attained wide fame during the war, Berdan being promoted to the rank of General at Bull Run (Catton, 1952).

The supplemental information Finley sent his uncle was the more interesting. General Hazen, in 1886, had asked a board of examiners consisting of a military man and two civilian scientists to rule on the competency of the group of officers trained at Ft. Myer in 1885. The board's first report satisfactorily passed all officers. Hazen did not accept the report and asked for specifics on each officer as to their full competency in each area, both scientific and military. The board could not guarantee that the officers were wholly competent to perform any duty that might be assigned, but added that each officer had passed a far more difficult examination than was required of the line officers of the Army.

According to Finley, when Greely released this information to the press it took the form that the officers were "wholly incompetent to perform their duties." Finley's letter to Berdan concluded with the fact that the scientific members on Hazen's board of examiners in 1886 were also judges on the board that awarded him "First Prize for the best scientific essay on Tornadoes" in early 1890.

Berdan forwarded Finley's information to the Adjutant General's Office of the War Department requesting that the Secretary of War be made aware of the contents. On his own accord Berdan forwarded an article that appeared in the Washington Star during November 1890. The article was quite favorable to the Signal Corps and its efforts in the field of weather forecasting. It presented the difficulties faced by the forecaster and the procedures involved in arriving at a forecast. The portion of the article that riled Berdan admitted that the forecaster must have a knowledge of the science of meteorology, but said that experience was the dominant factor in arriving at a successful forecast. The article summed up its argument by stating that "a man who has had three months of actual experience as a prognosticator is worth ten who have spent half their lives in the mere study of what ought to happen if everything went off according to program, which it never does" (Washington Star, 1890). Berdan enclosed a list of Finley's published papers and the various scientific societies of which he was a member, and concluded that "he [Finley] had reason to believe that General Greely was working against him" (Finley Papers, 1890d). In addition, Berdan included the favorable press clippings on Finley's successful West Coast forecasts.

There is no doubt that Finley's petitions and the influence of his uncle carried much weight with the Secretary of War as the names of all surplus Second Lieutenants in the Signal Corps were submitted to Congress for nomination into the Line of the Army in January 1891 (Finley Papers, 1891a). Finley was notified on February 7, 1891, that he had been commissioned as Second Lieutenant and assigned to the 19th Infantry. He immediately proceeded to submit his name for promotion to First Lieutenant before a board of officers convened for the examination of officers for promotion at the Presidio in San Francisco. On March 23, 1891, the board rendered the decision that Finley was "deficient in the professional qualifications necessary to enable him to perform efficiently the duties of the grade of 1st Lieutenant of Infantry" (Finley Papers, 1891b). The board added, however, "in view of the somewhat unusual circumstances attending this case the Board respectfully commend him to the favorable consideration of the War Department." The promotion board was well aware of Finley's political connections and deftly passed the case on to the War Department for the final decision. It was a favorable one. Finley was promoted to First Lieutenant effective July 15, 1891, and assigned to the 9th Infantry (Finley Papers, 1891c). He remained in charge of the San Francisco Forecast Office until relieved of this post in October 1891 by the Chief of the Weather Bureau, Mark A. Harrington, the first civilian head of the Bureau.

Finley was stationed with the Weather Bureau in Washington from November 1891 until May 1892, although his official military post was Madison Barracks, Sackets Harbor, N.Y. While in Washington, he was assigned the task of compiling a special report on the climatology of the Dakotas, a document ordered published by the 52nd Congress. It appeared in print under the title "Certain Climatic Features of the Two Dakotas" in 1893; it was his last official weather publication for the government. Finley left Washington in May 1892 and was assigned once more to the San Francisco office of the Weather Bureau under orders of the Secretary of Agriculture (Finley Papers, 1892). The act of October 1, 1890, transferring the weather duties of the Signal Corps to the Department of Agriculture had provided that "officers of the Army, not to exceed four, expert in the duties of the weather service may be assigned to duty with the Weather Bureau..." (U.S. Congress, 1890). However, as Truman Abbe states in his book on his father, Cleveland Abbe, "law authorized four Army officers paid by the War Department to be assigned to the Weather Bureau and only two were assigned at the time" (Abbe, 1955). One was Major S.S. Rockwood, who was Assistant Chief of the Weather Bureau under Harrington. The other was John Park Finley. While Finley was detailed to the Department of Agriculture, he published newspaper articles and lectured throughout California during the period May to October 1892 (Finley, 1925).

Finley's career as a military meteorologist came to an end on October 27, 1892, when he was ordered to join his regiment in the 9th U.S. Infantry at Fort Ontario, Oswego, N.Y. Although his primary interest was still meteorology, the civilian control of the weather service was complete, and Finley, who had fought for and won his military status, chose to return to military duty. A brief military document succinctly covers his position:

> "Lt. Finley, who upon reduction of the Signal Corps, and the transfer of the Weather Bureau to the Agricultural Department, was transferred to the 9th Infantry, was one of the officers detailed to the Weather Bureau under the Act of October 1, 1891. He remained on that detail until October 1892 when he asked to be relieved and to join his regiment, stating that he desired to give his whole attention to his military duties. The Secretary of Agriculture approved his request and added that Lt. Finley has "proven an able and efficient officer." Lt. Finley was accordingly relieved and ordered to join his regiment" (Finley Papers, 1893).

2. FINLEY'S THEORIES ON TORNADOES AND TORNADO FORECASTING

Finley's career as a military meteorologist was notable for his continuing struggle to convince the Signal Corps that tornadoes could be predicted. When Finley departed from the Weather Bureau in 1892 to become

a full-time infantry officer, he left behind a base of concepts that would be mulled over through the years by those interested in severe storms. His works would be cited as additional information became available with the advent of upper air observations and reconstructed theory.

Finley believed from the start of his tornado investigations that tornadoes and severe local storms could be predicted. In his first published work he suggested that an observer be stationed in Kansas City, Mo., who would receive special reports from Washington and forewarn the residents of the Lower Missouri Valley of any tornado potential. The evolution of Finley's rules for the prediction of tornadoes began in 1881.

> "As an area of low barometer (not necessarily a storm area) advances to the Lower Missouri Valley warm and cold currents set in towards it from the north and south respectively [sic], which, if the low pressure continues about stationary for some time, ultimately emanate from the warm and moist regions of the Gulf and the cold and comparatively dry regions of the British Possessions. Here lies the key to the marked contrasts of temperature and moisture, invariably foretelling an atmospheric disturbance of unusual violence" (Finley, 1881).

Finley went on to comment that the topography of the area (Great Plains) was most conducive for the meeting of these contrasting air masses, and "as far as the history of tornadoes is concerned the majority have occurred over this region." He added that the mountains to the west of the plains "deflect the course and modify the temperature and moisture of passing currents." Finley insisted, in all his subsequent writings, that it was in this area of contrasting air masses, which he referred to as the "battle-ground of tornadoes", that tornadoes formed.

He also recognized the presence of "an elongated barometric trough" in the storm system that produced the tornadoes. However, he did not pursue the importance of this particular pressure configuration as a steering mechanism for his "contrasting temperature and moisture" patterns until it was elaborated upon in a note in Science several years later. Figure 2 is a map from Professional Paper No. 7 (Finley, 1884a). Finley used this map to substantiate his argument that severe storms occurred at the juncture of conflicting temperature and wind fields. A conventional frontal analysis of today has been superimposed to show that these contrasting temperature and wind fields were the result of an instability line (a line of thunderstorms) in the warm sector of a surface cyclone. The concept of frontal analysis was unknown at that time, but Finley was correct in his assessment of the location of tornado formation, since a strong instability line often causes a reduction in temperature and a shift in the wind field that can last for several hours.

MAP "A,"

Showing the Pressure, Temperature and Wind Direction, at about 3 p.m., June 12, 1881, over the territory visited by the violent tornadoes and hail storms of that date.

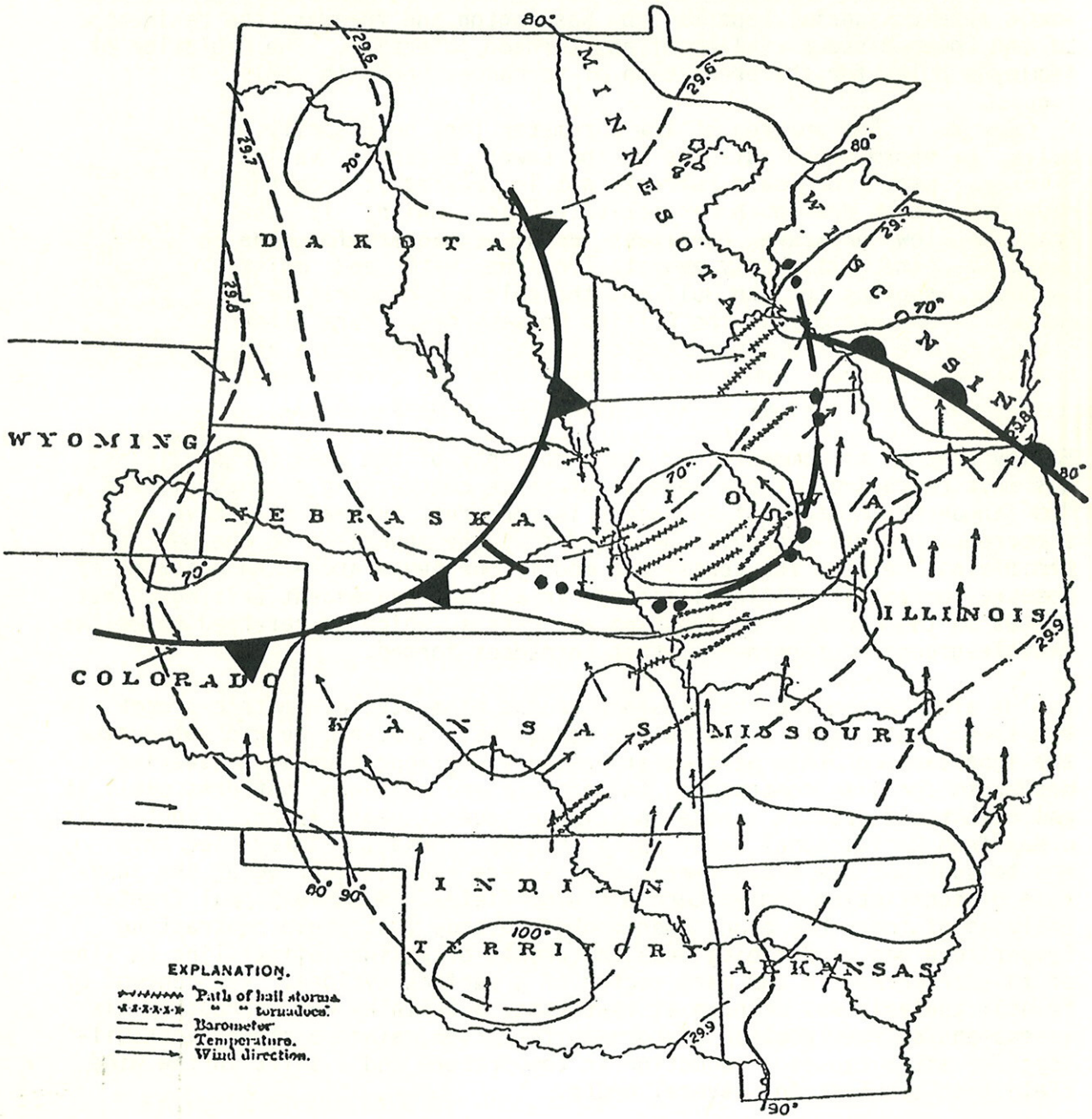

Figure 2. Finley's surface weather map for June 12, 1881. Fronts and stability line have been added to depict present day map analysis (Finley, 1884b).

A methodical worker, Finley began in 1877 to compile a list of all published reports of tornadoes dating back to 1794. This list provided a base for an extensive climatology on tornadoes, which would grow during the years of his investigations and would be cited often by contemporary and future researchers in the field of severe local storms. Finley's data included a distribution of tornadoes by state, month, time of day, path length and width, translation, estimates of wind speed, and many other characteristics of tornadoes. Along with this climatology Finley set forth suggestions for a method of investigation after the occurrence of a tornado (known today as a "tornado survey"), and provided safety precautions for those who found themselves in the path of a tornado. He also suggested the construction of tornado cellars or caves for persons living in regions frequented by tornadoes and the ringing of church and school bells "in some peculiar manner" to forewarn the approach of a tornado (Finley, 1884b). Although they were not the focus, embryo rules for tornado prediction also appeared. They included Finley's tenet on contrasting air masses, the frequent occurrence of tornadoes in the southeast quadrant of a low pressure system, a knowledge of the areas with maximum tornado frequency for each state, and insight into the occurrence of tornadoes in certain regions of the country, in certain months of the year. Finley's compilation appeared 1882 but was suppressed "on account of many typographical errors" (Finley, 1888).

While this major publication lay dormant, awaiting correction, the opportunity to pursue his goal of tornado prediction was enhanced by Finley's assignment to the Tornado Studies project in the spring of 1882. From his base of operations in Kansas City, Finley traveled almost constantly during the spring and summer months investigating tornadoes throughout the Midwest. The rigor of this method of operation was too great a burden for one man, and out of necessity he devised a plan to establish a corps of "tornado reporters" in order to obtain the desired information. He solicited from this voluntary group detailed descriptions, instrumental observations, photographs, diagrams, charts, and illustrations on tornadoes that they observed (Finley, 1882). He would no longer work in the field investigating individual tornadoes but would become the clearing-house and researcher on the information sent to him by the tornado reporters. He wrote later (Finley, 1884c) that he sought these results:

> "1. To determine the origin of tornadoes, and their relation to other atmospheric phenomena;
>
> 2. to determine the geographical distribution of tornadoes, and their relative frequency of occurrence in different states, and different parts of the same state;
>
> 3. to determine the conditions of formation with a view to the prediction of tornadoes;

4. to determine the means of protection for life and property;

5. to determine the periodicity of the occurrence of tornadoes, and their relative frequency by seasons, months, parts of months, and time of day;

6. to determine the prevailing characteristics of tornadoes;

7. to determine the relation of tornado regions to areas of barometric minimum."

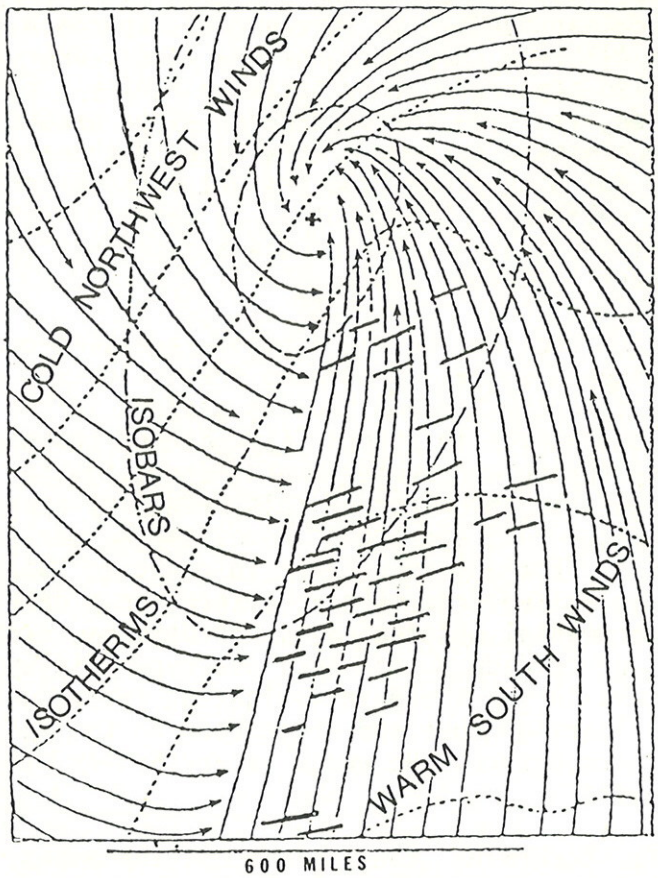

Figure 3. Interpretation of Finley's tornado formation with respect to the surface low pressure and wind field (after Davis, 1884a).

Essentially, Finley had arrived at conclusions in the suppressed report on tornado characteristics of 1882. The formation of the tornado reporter network would provide additional data to confirm or deny those conclusions. As Finley stated in 1886, there was opposition to this plan: "Some have said: Study one tornado thoroughly and you have exhausted the subject. Had we stopped at this point some years ago, the possibilities of prediction would have remained a myth" (Finley, 1886).

In 1884 the suppressed publication on tornado characteristics was finally published as Professional Paper No. 7 of the Signal Service. It was also in 1884 that Finley received unexpected support from Science (Davis, 1884a), which published a figure showing the average of three sets of charts depicting the surface pressure, temperature, and wind patterns of large tornado outbreaks that occurred on February 19, March 11, and March 25 of 1884 (Figure 3). The charts has been prepared by Finley and released by the Signal Corps. In the discussion of the figure, the editor pointed out the position of the tornadoes in relation to the cyclone center (southeast) and the warm and cold winds. He continued, "with longer and more detailed study, the smaller storms may, a few years hence, be predicted with as much accuracy as the larger ones are now."

A following issue of Science contained an article by Finley (1884c) in which he reported on the progress of his tornado investigations. He listed a series of relationships he observed from the information sent him by the tornado reporters and a study of the daily weather maps for the past year. Although he stated that these were the principal "results" of his study, they are in fact the first formal listing of rules for tornado prediction:

> "1. That there is a definite portion of low pressure within which conditions for the development of tornadoes is most favorable; and this has been called the "dangerous octant".
>
> 2. That there is a definite relation between the position of tornado regions and the region of high contrasts in temperature, the former lying south and east.
>
> 3. That there is a similar relation of position of tornado regions and the region of high contrasts in dewpoint; the former being, as before, south and east.
>
> 4. That the position of the tornado regions is to the south and east of the region of high contrasts of cool northerly and warm southerly winds, - a rule that seems to follow from the preceding, and is of use when observations of temperature and dewpoint are not accessible.
>
> 5. The relation of tornado regions to the movement of upper and lower clouds has been studied, and good results are still hoped for.
>
> 6. The study of the relation of tornado regions to the form of barometric depressions seems to show

that tornadoes are more frequent when the major axis of the barometric troughs trend north and south, or north-east and south-west, than when they trend east and west."

These rules were restated by Finley in 1886, and he also listed "features of map study that must receive consideration in the preparation of a tornado prediction for any day" (Finley, 1886):

"1. Barometric trough. Region. Ratio of axes. Pressure. Departure from normal.

2. Central area of barometric minimum. Region. Pressure. Departure from normal.

3. High contrasts of temperature. Region. Gradient.

4. High contrasts of cold northerly and warm southerly winds. Region.

5. High contrasts of dewpoint. Region. Gradient.

6. Heaviest lower cloud formation. Region. Kind.

7. Opposing movement of lower clouds. Region. Directions.

8. Coincident movement of upper and lower clouds. Region. Direction.

9. Opposing movement of upper and lower clouds. Region. Direction.

10. Opposing movement of lower clouds and winds. Region. Direction."

Finley's rules for the prediction of tornadoes appeared in print one last time when the American Meteorological Journal sponsored a contest for prize essays on tornadoes in 1888. Finley won first place in the contest with his essay, but political overtones (the imminent transfer of the weather service to civilian control), the continuing conflict between the military and civilian meteorologists of the Signal Corps, plus the low esteem in which Finley was held by his superiors, negated the opportunity to put into practice the routine issuance of tornado predictions for the public.

Finley was not lacking for critics. There were those who took exception to a particular statement or portion of Finley's publications, and there were those who entirely ignored his scope of work and postulations.

Finley's most outspoken adversary was Professor H.A. Hazen, a civilian employee of the Signal Corps. Hazen, a brilliant and well-educated man, had been recruited by General W.B. Hazen (no relation) to work in the study room in May 1881, having been assistant in meteorology and physics under Professor Elias Loomis at Yale University. Hazen's activities and investigations in the study room ranged from the proper exposure of thermometers, atmospheric electricity, balloon ascensions, and psychrometry to the study of thunderstorms and tornadoes. It was the latter that led him into controversial exchanges over tornado postulation with Finley.

After the abolition of the study room in 1886 by order of the Secretary of War, Hazen was assigned to the Records Division as an assistant to Finley. The strained relations between the military and civilian meteorologists that existed at the central office of the weather service in Washington are exemplified in the public exchange between Finley and Hazen in the American Meteorological Journal. Hazen, in a letter to the editor questioned who was first to mention the fact that tornadoes do not occur at the center, but rather in the southeast quadrant of an area of low pressure. He continued that credit on this point had been given to Finley's Professional Paper No. 7 but pointed out that "the author (Finley) considers that tornadoes occur in the southwest quadrant of the low area" (Hazen, 1888a). Hazen followed with an extract of an article that appeared in the Washington Post for March 30, 1884, in which Hazen stated that tornadoes occur in the southeast quadrant of a low pressure area. He concluded that "it may be wise to give it [the article] a more permanent form for reference." Finley, outraged, responded in a subsequent issue of the journal (Finley, 1888a). He methodically listed his publications between 1881 and 1883 stating that tornadoes form in the southeast or south-and-east of the low pressure area. He explained that the original Professional Paper No. 7 of 1882 contained many typographical errors and had to be suppressed. The corrected edition of 1884 did not eliminate all the errors, among them the use of the word southwest where it should have been southeast.

Hazen retreated from his position, announcing in a following article that his priority existed in the claim of "definite mention and emphatic calling attention" to this particular law of tornado development (Hazen, 1888b). He added that tornadoes occur to the southeast of a storm center from 300 to 600 miles away and where there are absolutely no northerly winds and no contrasts of temperature. Finley, still smarting from Hazen's original article, countered with "this is too low a standard by which to judge my rights in the matter.... Of all the ways of retreating from an indefensible position, the method adopted by Prof. Hazen is both unique and original. He makes a claim which he is not entitled to" (Finley, 1888a). Since the existence and life cycle of instability or squall lines was not fully recognized by the meteorological community at that time, both parties were partially right. Hazen was looking at the broad synoptic pattern under which tornadoes form, while Finley was basing his postulation on the manifestations of the squall line.

Although Finley won the battle about who was first to recognize the fact that tornadoes occurred in the southeast quadrant of a low pressure system, Hazen remained undaunted and continued to criticize Finley whenever the opportunity presented itself. Hazen published a book on tornadoes (Hazen, 1890) which not only highly criticized Finley's efforts in the field of tornado investigation but also disputed the writings of prominent theorists in the field of tornado and thunderstorm formation (Professors James P. Espy, William Ferrel, and William M. Davis). Besides denouncing once more Finley's stand that tornadoes form at the juncture of hot south winds and cool northerly winds, he challenged many others of Finley's observations. Hazen wrote that there was no rotation in the tornado, no updraft -- "the apparent drawing up of water from a pond cannot be regarded as evidence of an uprush (updraft)," and he denied that the tornado roar was caused by the wind.

Finley, along with others, rejected the once popular theory that tornadoes were caused by atmospheric electricity. Hazen attributed the depluming of fowls to "the supposition that an electric charge threw off the feathers, and this seems the only way of explaining the stripping of clothes from a person (caught in a tornado)." Hazen chided Finley for making no effort to classify tornadoes as to violence or extent, "but (he) would take any funnel-shaped cloud, whether it reaches the earth or is seen in the clouds, and give it a county, date, time of occurrence, direction of motion, shape of cloud, and width of path." Finley considered the tornado a meteorological event to be recorded, no matter how weak or strong, and he came to the realization that the tornado was not the rare and special event it was believed to be at the time.

Another vocal critic of Finley was Dr. Gustavus Hinrichs, director of the Iowa Weather Service, who in an invited article for the American Meteorological Journal (Hinrichs, 1888) rebuked Finley for his method of compiling tornado statistics. Hinrichs coined the term "derecho" or "straight blow of the prairies" as opposed to the twisting column of air in the tornado. He defined derecho as "a powerfully depressing and violently progressing mass of cold air, [in Iowa] generally towards the southeast ..." associated with a thunderstorm. This phenomenon is commonly called the thunderstorm gust or straight line wind but has also been referred to in the past as the "plow wind" and most recently, the "downburst."

What riled Hinrichs was a paper on tornadoes in Iowa by Finley (1888b). Hinrichs stated in his article that "A goodly number of these tornadoes have never existed outside the archives and publications of the Signal Service, and a great many others were simulations." He accused Finley of confusing the tornado with the derecho and combining both storms in one set of statistics. He wrote that "Lists giving all sorts of storms and mere cloud phenomena, inextricably mixed up with genuine tornadoes, cannot form the basis of any scientific study whatever." Hinrichs proceeded to methodically dissect and discredit Finley's list of Iowa tornadoes by citing information he had gathered on individual storms during his

13 years as director of the Iowa Weather Service. He concluded that Iowa averaged one notable and one minor tornado event per year stating, "Our record averaging one real tornado a year is bad enough, and needs no amplification by professional tornado manufacturers." However, Hinrichs's list of notable tornadoes included not only single devastating tornadoes but also multiple tornadoes (tornado outbreak) that caused widespread havoc on a single day. Thus, Hinrichs was referring to the number of tornado days while Finley listed individual storms. Both viewpoints are acceptable and the practice today is to record both.

In a different area, Finley was challenged on his verification statistics for tornado prediction (Finley, 1884d). G.K. Gilbert, a geologist with a flare for statistics, objected to Finley's method (Gilbert, 1884). He stated that, although Finley's work showed "encouraging progress," he wished to point out a fallacy in that Finley assumed that verifications of predictions of a rare event could be classed with verifications of the predictions of frequent events, without any system of weighting. He noted that the occurrence of tornadoes in any one of the districts indicated by Finley is highly exceptional and that their non-occurrence is the rule. This consideration was overlooked in Finley's verification system. By using dualistic prediction (conditions favorable and unfavorable for tornado activity) Finley achieved a 96.6% degree of success. Gilbert demonstrated that by predicting the non-occurrence of tornadoes for each district and each time period used by Finley, a 98.2% degree of success could be attained. He then showed that excluding all Finley's non-occurrence predictions and using only his positive predictions gave Finley a 23% degree of success at predicting tornadoes.

Professor Hazen challenged both Finley's and Gilbert's tornado verification schemes in an article written in 1885 but not published until 1887 (Hazen, 1887). Hazen's answer was a weighting system in which he assumed "that tornadoes occurring in a district half way between the center and edge shall have the weight of 1; in the rest of the district 3/4; to the center of the district outside (adjacent) 1/2; to the outside of that 1/4; all outside of these 0." Thus, not only would a successful forecast of tornadoes for a district receive credit; it was also possible to receive partial credit from an adjacent district(s) (see Fig. 1). Hazen took Finley's tornado predictions for June 1885 and showed by using his system that the verification was 49% correct. Surprisingly, this appears to be in defense of Finley. However, Hazen's concluding remarks include the statement, "It seems probable that the division of the country into districts, in each of which predictions are to be made, is hardly wise."

Finley did have his supporters. Among them was W.M. Davis, a professor of meteorology at Harvard University. Finley had published preliminary charts on the tornado outbreaks that occurred in February, March, and April of 1884. Davis made a study of these charts, which appeared in Science (Davis, 1884a). He supported Finley in the concept that tornadoes occur in the southeast quadrant of a storm system. Davis presented a diagram (Figure 3) designed to show the relation between the

wind and temperature fields, the cyclone center, and the location of tornado occurrence. His diagram was an average of the three sets of charts presented by Finley. More importantly, he published an in-depth discussion of these charts in the American Meteorological Journal (Davis, 1884b). He observed that it was possible that "the larger cyclonic circulation carries cool air over warm air, and thus produces the distinctly unstable atmospheric equilibrium necessary for the development of violent local storms." He continued, "this relation has already been more or less distinctly perceived ... but has never had such proof as it finds in Mr. Finley's tornado charts of this year." Figure 3 approximates the classic surface configuration accepted by meteorologists today for the formation of severe local storms.

Davis also praised Finley for an entirely different effort -- Finley's "Monthly Storm Track of the Northern Hemisphere." In a review of this paper for the American Meteorological Journal, Davis wrote, "Lt. Finley has performed a valuable and laborious task in bringing together so large a share of the trustworthy data concerning the attitude of storm-centers, gathered in the last twenty years" (Davis, 1885).

Support for Finley came from a different sector of the academic field but only after he had been replaced by General Hazen as the Signal Corps authority on tornadoes. Alexander McAdie, a doctoral candidate at Clark University in Worcester, Mass., won Second Prize in a contest on tornadoes sponsored by the American Meteorological Journal (Prize Essays, 1890). In his essay McAdie rebuked the Signal Corps for not openly predicting the possibility of tornadoes and accused the Weather Service of "cloaking" the fact under the term "severe local storms." He added, "Nor can the commotion and alarm of a community fearful of misdirected prediction, be fairly weighed against the benefits and advantages to a community warned of the likelihood of a tornado, in that section or county, within a given time."

In a similar vein, McAdie challenged the Signal Corps to reissue (prepare) a special chart that he called "The Tornado Chart," which was begun in July 1886 and, after two years, was discontinued for reasons not made public. Also, for reasons unknown, no mention of such a chart was made in the reports of the Chief Signal Officer during the period it was prepared, nor did Finley refer to it in his sections on tornado studies in those reports. The charts were prepared to assist the indications officer in locating areas of possible severe local storm formation. They included the ten features, or parameters listed by Finley (1886). The regions of northerly and southerly winds were distinguished by heavy carbon lines (a suggestion of Finley's and one that hints of frontal analysis). McAdie echoed the sentiments of Finley that additional parameters be added to the chart and argued that the predictions of tornadoes should be resumed. The tornado chart was quite similar to the present day "composite chart" prepared by severe storms forecasters using surface and upper air parameters that are conducive to the formation of severe local storms.

3. FINLEY AS A MILITARY ADMINISTRATOR

Finley left the Weather Bureau and active involvement in meteorology in 1892. He was next assigned to a company of the 9th Infantry stationed at Ft. Ontario, Oswego, N.Y., where he performed company duties. He remained there until October 1893 when he reported to Madison Barracks, Sackets Harbor, N.Y., headquarters of the 9th Infantry (Finley Papers, 1897). He did not wholly lose his interest in weather as he wrote and lectured on meteorological subjects (Finley, 1925). In August 1895 he was sent to the U.S. Infantry and Cavalry School at Ft. Leavenworth, Kan. The school had a 2-year curriculum, but Finley left in July 1896 when the opportunity to become Quartermaster of the 9th Infantry was afforded him. He returned to Madison Barracks (Finley Papers, 1896).

The 9th Infantry was ordered to Tampa, Fla., in April 1898, but Finley and a cadre of about 20 men remained at Madison Barracks on a housekeeping detail with Finley in command. In June 1898 the Secretary of War received a complaint that cited Finley for "hard labor", noting that "the treatment men receive is sufficient to drive them to desertion" (Finley Papers, 1898). Finley's work and disciplinary habits were obviously not appreciated at Madison Barracks. Since the complaint was signed "anonymous," no formal action was taken against Finley.

In the meantime, Finley had applied for promotion to Captain. This was favorably acted upon in February 1899. A month later he was ordered to the Philippines but his stay was short. He contracted chronic neuritis and dysentery and was hospitalized from July through October 1899. It was recommended that he be returned to a cooler climate, and he arrived in the States in November 1899 (Finley Papers, 1899). Finley was assigned a 2-year detail in the general recruiting service and entered upon these duties January 1, 1900, at Syracuse, N.Y.

Finley remained at Syracuse with recruiting duties until he rejoined the 9th Infantry in August 1902. Shortly thereafter, he was transferred to the 27th Infantry and ordered back to the Philippines, arriving there in November 1902. He performed regimental duties until March 1903. He was then named Acting Judge Advocate and assigned to Zamboanga, Mindanao. In September 1903 he was appointed Civil Governor of the district of Zamboanga, where his ability as a military administrator was to be recognized (Finley Papers, 1903).

The island of Mindanao and the Sulu Archipelago are inhabited by the Moros. In 1903 they were a fierce and savage race of mixed Malayan stock who were converted to the Moslem religion some four or five centuries prior to the Spanish-American War. The Moros were tribal by nature without central authority. When they were not attacking settlements, they would wage war with each other. The goal of the military was to subdue and pacify the Moros and meld them into the Philippine economy. Most times the means applied resulted in the use of force. When Finley became Governor of the Zamboanga district, he called a meeting of the Moro chief-

tains in the area and informed them of his wish for them to disarm. Finley's approach included frequent meetings with the tribal chiefs and persistent persuasion. He would make his inspection trips traveling alone and unarmed, spending nights in the native villages (Finley Papers, 1912). He also established the Moro exchange system, setting up markets where the Moros could bring their wares to sell without fear of being victimized by the coastal traders.

The first exchange began operation in the city of Zamboanga in September 1904, and by July 1911 there were 31 exchanges throughout the Moro Province. However, not all the tribes accepted Finley's order to turn in their arms or the concept of the exchanges. Finley commanded five expeditions against hostile Moros between 1905 and 1911 and subdued them by force. Nonetheless, the overall success of his pacification methods was widely acclaimed back in the United States, and a number of dignitaries and inspection groups, among them William Jennings Bryan and a commission appointed by President William Howard Taft, toured the Moro Province and the exchanges for "on the spot" investigation (Finley Papers, 1912). Naturally, Finley acted as the tour guide.

Finley had not completely divorced himself from his interest in meteorology. He wrote and gave lectures primarily on the typhoons and monsoon season for the area of the Philippines (Finley, 1925). A note he sent to the Monthly Weather Review (MWR), which appeared in the February 1909 issue, listed meteorological terms in English, Spanish, Malay, and two Moro dialects. He had translated one of the latter into both English and Arabic, but the Arabic was omitted from the MWR note (Abbe, 1909).

While he was Governor of Zamboanga, Finley was promoted to Major in December 1907. It was also in this period that his weight went out of control, increasing to 260 pounds. However, it was written that Finley was "...a man of large and powerful frame and of unusual strength.... From my personal knowledge he can walk, and has walked, all day long in this climate, over mountains and through tropical jungles" (Finley Papers, 1908). There was reason for this comment. In an era when the horse was the mode of travel for the Army, Finley was poor in horsemanship and because of his weight, he required two mounts to complete the periodic riding test, each mount going half the prescribed distance.

During this time his military prominence reached an apex. Late in 1909 Brigadier General John J. (Black Jack) Pershing replaced Finley's benefactor, Major General Leonard Wood, as commander of the Moro Province. At first, all seemed to go well between them but procedural differences proposed by Pershing in the operation of the Moro exchanges resulted in a petty feud, flamed by personalities, politics, and prestige. Pershing increased the scope of the exchanges and re-named them industrial trading stores. Finley supporters accused Pershing of capitalizing on a long-existing successful project for his own interests (Vandiver, 1977). Pershing, not one to avoid a battle, retaliated by indirect criticism in Finley's efficiency ratings with such notations as "best suited at college

level or recruiting," "poor in horsemanship," etc., (Finley Papers, 1911) and more directly to Senator Francis E. Warren (Wyo.), Chairman of the Military Affairs Committee (who was also Pershing's father-in-law). He wrote to Warren, "Finley is an old pessimistic wind bag of the most inflated variety .... He is brusque, gruff, overbearing and exclusive" (Vandiver, 1977).

An opportunity came for Pershing to replace Finley when a group of Moro leaders petitioned for Finley to be their Minister Plenipotentiary to the Sultan of Turkey and obtain for them the Sultan's assurance that the laws, aims, and aspirations of the American government were in accord with the Moslem religion. This mission was approved by the Secretaries of War and State, and Finley was recalled to Washington, D.C., in May 1912 to await further orders. There was a delay in sending Finley to Turkey, possibly because it was a presidential election year. Meanwhile, pressure on Finley continued. A report from the Philippines to the Secretary of War, received in May 1912, stated that Finley had resigned his governorship in March 1912. Finley denied the report, since he was expecting to return to Zamboanga after his visit to Turkey (Finley Papers, 1913a).

Finley finally received orders to proceed to Constantinople in February 1913 to complete his mission for the Moros and then to report back to Zamboanga. This prompted a memo from the Governor General of the Philippines quoting Pershing: "Finley has outlived his usefulness in the Moro Province" (Finley Papers, 1913b). Finley arrived in Constantinople and received an audience with the Sultan (Shiekh-Ul-Islam) on May 22, 1913. He received letters of reassurance from the Sultan for delivery to the Moro leaders and was publicized and decorated by the Turkish government in recognition for his work among the Moro tribes.

Arriving back at Zamboanga in July 1913, Finley was notified that he had been promoted to Lt. Colonel. His stay at Zamboanga was short for he was assigned to the 13th Infantry and ordered to Manila. His work among the Moros, except for a few weeks in early 1914, was over. He never regained the governorship of Zamboanga. The effects of his feud with Pershing were still exacting their toll when late in 1913 a cablegram was received at the War Department from Maj. Gen. J. Franklin Bell, Commander, Division of Philippines. It stated, "My knowledge his work [Finley's] during past three years and present apparent mental attitude leads me to conclude [he] has already been in the tropics too long" (Finley Papers, 1913c). Bell went on to recommend that Finley be relieved and assigned to duty in the United States. Finley finally left the Philippines in September 1914 and reported for duty to the 29th Infantry at Ft. Niagara, N.Y. He had lost his feud with Pershing. Nevertheless, he had done good work among the Moros. His papers on the subject reside at the Hessian Guardhouse Museum (U.S. Army Archives and Historical Library) in Carlisle Barracks, Pa.

Finley concluded his military life in relative obscurity. He served two years in Texas on border patrol, had brief duty at the Army War College, and was finally stationed at Ft. Jay, Governors Island, N.Y., as Officer in Charge of Militia Affairs until his retirement on April 11,

1918. He was 64 years old, had completed 41 years of military service, and had been promoted to full Colonel in July 1916. His retirement was brief, for he was recalled two weeks later and placed in command of the Students Army Training Corps (SATC) for the New York City area until February 1919, when he retired a second time.

4. FINLEY, THE METEOROLOGICAL CONSULTANT

After his final retirement from the military, Finley became a private meteorologist, and in 1920 he established the National Storm Insurance Bureau in New York City. (This company later was renamed the National Storm and Aviation Insurance Bureau.) Using the vast accumulation of climatological data he had amassed over the years, he provided insurance underwriters with assessments of risk to life, property, and crops from tornadoes, windstorms, and hail for all areas of the country. He also provided storm track frequencies, maximum and minimum rainfall values, and descriptions of weather conditions that increased risk to crops from insects and disease. He was well known throughout the insurance field, as his publications and lectures before various insurance groups attest (Finley, 1925). Finley also became a charter member, charter fellow, and contributing member of the American Meteorological Society. In the late 1920's he became interested in aviation weather and wrote numerous weather surveys following aviation disasters.

Finley returned to his native Michigan in 1932 and opened the National Weather and Aviation School in Ann Arbor. A 1939 brochure for the school stated, "the work covers the fields of theoretical and applied meteorology and climatology. Particular attention given to weather forecasting, especially in its vital relation to aviation. Instruction by correspondence" (Finley, 1939). The brochure also indicated that statistical compilations, weather surveys, and investigations would be conducted in the commercial, agricultural, industrial, and social fields. Finley was now 85 years old. Four years later, on November 24, 1943, at the Percy Jones Hospital in Battle Creek, Mich., John Park Finley died. He was survived by his two daughters of his wife Julia (who died during the 1930s), and by his second wife Flora C. Finley. The situation of his brother, Dr. Mark F. Finley, at the time of John Finley's death, has not been determined. John Park Finley's obituary appeared in the November 26, 1943, edition of the Ann Arbor [Mich.] News.

5. ACKNOWLEDGMENTS

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The NSSL Technical Memoranda, beginning at No. 28, continue the sequence established by the U.S. Weather Bureau National Severe Storms Project, Kansas City, Missouri. Numbers 1-22 were designated NSSP Reports. Numbers 23-27 were NSSL Reports, and 24-27 appeared as subseries of Weather Bureau Technical Notes. These reports are available from the National Technical Information Service, Operations Division, Springfield, Virginia 22151, a microfiche version for $4.00 or a hard copy, cost dependending upon the number of pages. NTIS numbers are given below in parenthesis.

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